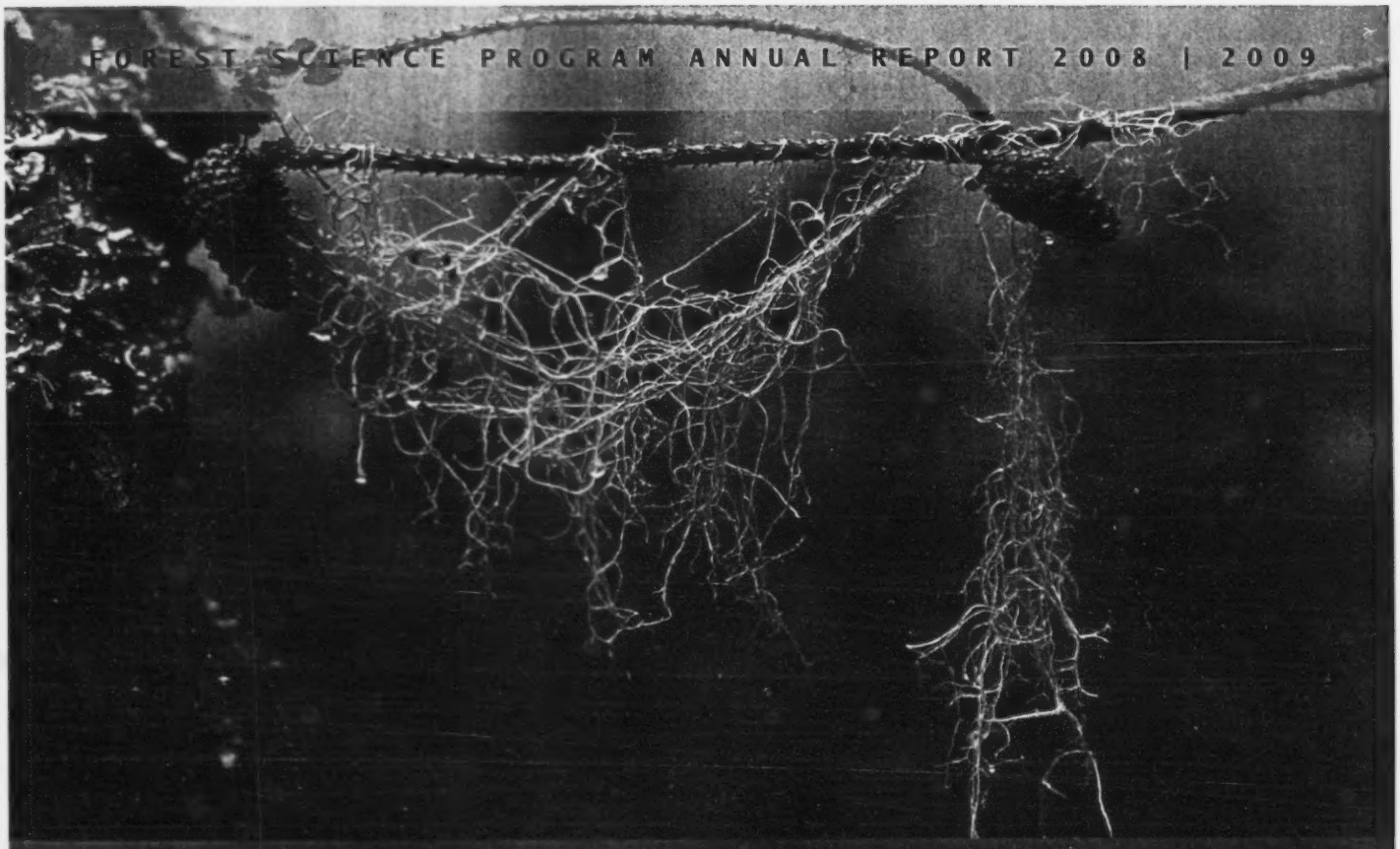
FOREST SCIENCE PROGRAM ANNUAL REPORT 2008 | 2009



science to support sustainability

08 | 09

BRITISH COLUMBIA

Ministry of Forests and Range

Forest Science Program Mission

The Forest Science Program is dedicated to:

providing innovative solutions to high-priority forest and range resource management issues; and

seeking opportunities to advance resource stewardship based on sound scientific principles.

Abbreviations

BCTS—BC Timber Sales

BEC—Biogeoclimatic Ecosystem Classification

C&E—Compliance and Enforcement

EBM—Ecosystem-based Management

FFEI—Future Forest Ecosystems Initiative

FIA-FSP—Forest Investment Account-Forest Science Program

FREP—Forest and Range Evaluation Program

FRPA—Forest and Range Practices Act

FSP—Forest Science Program

LTSP—Long-term Soil Productivity

MFR—Ministry of Forests and Range

MPB—Mountain Pine Beetle

TASS—Tree and Stand Simulator

UWR—Ungulate Winter Range

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Director's Message

I am pleased to present the Forest Science Program's (FSP) Annual Report for 2008/2009. This year's report theme, Climate Uncertainty—Preparing for the Future, reflects the era of forest and range management that British Columbia has entered, and also points to how the Forest Science Program, with its wealth of expertise and legacy of research, has responded constructively to the province's newest challenges.

Providing the scientific foundation for developing appropriate policy and management responses to climate change was a significant assignment this year for many FSP researchers. Their multi-faceted contributions drew heavily from a core research foundation that the FSP has built over many decades of persistent effort. Together, these assets of skilled staff and mature research foundation offered the Ministry of Forests and Range (MFR) unprecedented scientific support for developing sound solutions to address future environmental uncertainty.

Of course, climate change was not the only focus of the FSP this year. The Program, as a whole, contributed to the MFR's strategic priorities for many aspects of forest and range management. Highlighted in this year's annual report are FSP research, extension, and consultation activities that addressed the impacts of the mountain pine beetle infestation, including those on the midterm timber supply. Other FSP initiatives supported implementation of the Coastal Forest Action Plan and the *Forest and Range Practices Act*. Partial cutting, integrated forest management, range management, species at risk, First Nations' culturally important plants, and tree seed orchard improvements and production also benefitted from the FSP's 2008/09 endeavours. Various management processes were created or improved, then tested and evaluated to enhance the effectiveness of the Ministry and of resource management in British Columbia. Along the way, FSP researchers provided training sessions, suggested solutions, and produced publications to ensure that science makes a difference on the ground.

Throughout, FSP researchers worked in partnership with MFR branch, region, district, and BC Timber Sales staff to address Ministry priorities. FSP researchers also frequently collaborated with British Columbian, Canadian, and international scientists who contributed valuable expertise to FSP projects. As detailed in this annual report, the results are extensive and the benefits widespread.

Winn Hays-Byl, Acting Director
Research Branch

Measuring permafrost at a landslide.

A. Forest Science Program Overview

A.1. Scientific Foundation for Forest and Range Management

British Columbia has entered an era of rapid environmental change coupled with increasingly diverse demands for products and services from its forests and rangelands. The unprecedented mountain pine beetle (MPB) epidemic that attacked British Columbia's pine forests has demonstrated how climatic warming can severely affect the province's valuable resources. In the insect's wake, new ways of using tree fibre are emerging, which have ecological and management repercussions of their own. With these mounting challenges, now more than ever, resource policy-makers and managers need sound science on which to base their decisions.

Measuring discharge from a small stream.

The British Columbia's Ministry of Forests and Range (MFR) Forest Science Program (FSP) is uniquely positioned to develop the scientific foundation needed to meet the province's forest and range management challenges. FSP researchers, located throughout the province, investigate diverse aspects of resource stewardship and sustainability in response to increasing management concerns. Furthermore, FSP staff share their scientific knowledge and findings with resource policy-makers and managers to help advance appropriate forestry and range practices.

A.2. Supporting the Ministry's Strategic Priorities

As suggested by this annual report's theme, Climate Uncertainty—Preparing for the Future, FSP researchers rallied this year in assembling the science required to assist the Ministry in preparing for climate change. The Program's contributions are expanded upon in Part B of this report.

Taking field measurements near Fort Nelson.

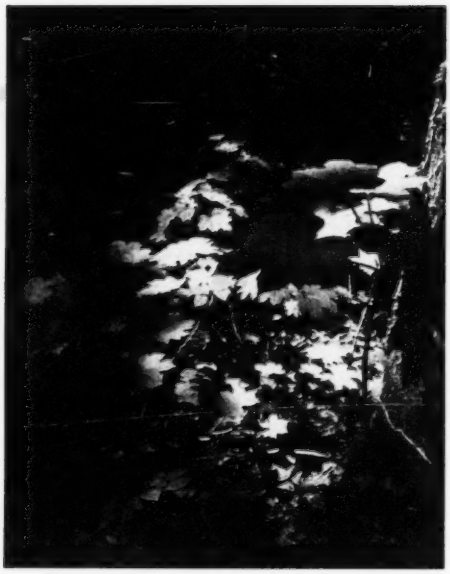
The FSP focuses specifically on supporting the current strategic priorities and initiatives of the MFR's Operations[1] and Forest Stewardship Divisions[2], and the Chief Forester[3]. This year's annual report provides examples of how the FSP addressed MFR priorities throughout the province. FSP research, extension, and consultation supported implementation of legislation, examined factors affecting the midterm timber supply, helped ameliorate impacts from the mountain pine beetle epidemic, and much more. These initiatives

[1] Operations Division Strategic Priorities 2008–09, April 2008.
[2] Memo from Jim Snetsinger to Forest Stewardship Division Staff Re: Summary of Forest Stewardship Divison Initiatives for Fiscal 2008/09, April 24/08.
[3] Chief Forester's Stewardship Vision and Framework, May 2007.

involved FSP researchers assisting staff in branches, regions, and districts with data and recommendations to support new policy initiatives; training courses and publications to guide management practices; and expertise to resolve site-specific issues. Part C of this report summarizes many of this year's accomplishments in support of Ministry priorities.

A.3. Clients and Collaborators

The FSP primarily conducts research, extension, and consultation to serve the needs and priorities of the MFR Executive, branches, regions, and districts, as well as BC Timber Sales (BCTS). Additionally, much of the Program's work contributes directly to other provincial resource management agencies, and the forestry and ranching industries. FSP initiatives benefit many other groups as well, including First Nations, local governments, conservation organizations, and the energy and mining industries.



Forest understorey on a moist site.

Forest Science Program clients are often project partners, as FSP staff typically work closely with them to best address their needs. Furthermore, FSP researchers frequently collaborate with other scientists at the Canadian Forest Service, and at universities and research institutions in British Columbia, elsewhere in Canada, and in Europe and the United States. The collaborative partnerships FSP researchers have built with clients and scientists bring an immense breadth of practical and scientific knowledge, skills, and expertise to bear in finding solutions to forest and range management issues.

A list of FSP clients in 2008/09 is presented in Appendix A, while partners and collaborators are identified in Appendix B.

A.4. Organizational Structure

The FSP comprises the Research Branch of the Forest Stewardship Division, and three regional research teams in the Operations Division. The Branch responds to provincial-level forest and range science needs with sections focussed on Forest Genetics, Ecology and Earth Sciences, and Forestry and Technical Services. Forest Genetics researchers conduct tree breeding, gene conservation, and genecology research, which include field trials and clone banks at the Kalamalka and Cowichan Lake Research Stations. Ecology and Earth Sciences staff specialize in soils, climatology, watershed hydrology, plant ecology, wildlife habitat, range ecology, and landscape ecology. While the Section is headquartered in Victoria, some staff are based in other

British Columbia communities. The Forestry and Technical Services Section houses expertise in strategic analysis, stand development modelling, silviculture systems, and forest dynamics. This Section supplies research support through the Ministry library, scientific and technical publishing, analytical chemistry laboratory, and finance and administration. A full list of topics addressed by the Research Branch, along with contact information, is available at:
http://www.for.gov.bc.ca/hre/topics.htm

FSP researchers stationed in the Ministry's regional centres work together with forest district and BCTS staff to scientifically address local and regional forest and range management needs. The regional researchers offer expertise in soils, ecology, and other biophysical research disciplines. The FSP sections, staff locations, and research disciplines are listed on the inside back cover of this annual report.

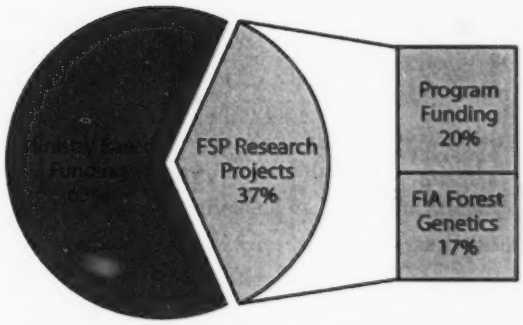


Figure 1 Forest Science Program funding.

A.5. Funding and Expenditures

Main funding for the FSP in the 2008/09 fiscal year came from three sources: Ministry base funds, the Forest Investment Account Forest Science Program (FIA–FSP), and the Forest Investment Account Forest Genetics Conservation and Management Program. The FSP's budget for the year was $18.3 million. Of this total, $11.6 million, or 63%, was comprised of Ministry base funding. This primarily covered essential fixed costs, including facilities maintenance operating expenses, corporate resources such as the Ministry Library, and staff salaries.

Most of the FSP's research projects were funded by either the FIA–FSP, totalling $3.585 million (20% of Program funding), or by the FIA Forest Genetics Program (17%). In 2008/09, FSP researchers garnered funding for 72 proposals through FIA's competitive process. Several research projects were funded by other collaborators, such as the Habitat Conservation Trust Foundation, the Department of Fisheries and Oceans, and the Okanagan Innovative Forestry Society.

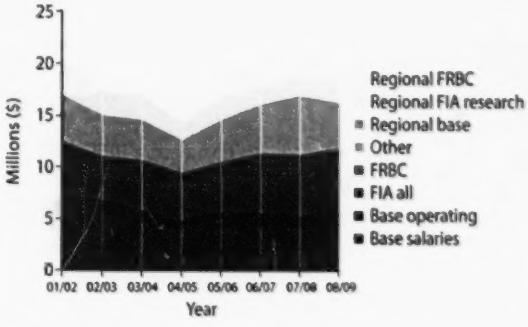


Figure 2 Forest Science Program funding: distribution of funds by funding source, 2001-2009.

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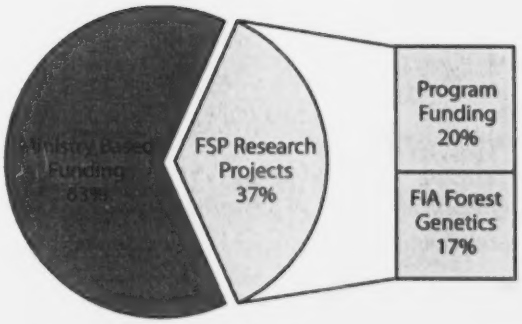

Total Budget: $18.3 Million

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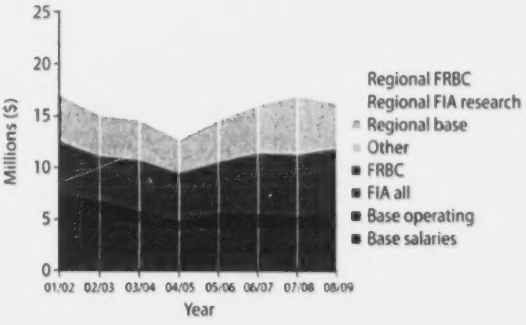

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Weather station being installed for a study tracking changes in climate and permafrost.

Landslide debris buries a forest road.

B. Climate Uncertainty – Preparing for the Future

B.1. Addressing Climate Uncertainty

Given the lengthy lifespan of British Columbia's native trees, maximizing forest productivity requires anticipating and preparing for future conditions in light of climate change. This section describes FSP researchers' progress this year in assembling the science necessary for making informed and logical forest and range policy responses to climate uncertainty.

Tracking Change

To keep abreast of environmental shifts, FSP researchers actively monitored changes due to climate. One change that is evident in northern British Columbia is the shrinking of permafrost. Degrading permafrost has caused mountain slope instabilities, which have resulted in landslides and may have played a role in some large earth flows on gentle topography. Tracking permafrost decline is a first step towards anticipating and preparing for these disruptive events. This year FSP researchers established permanent equipment installations for linking permafrost and weather data in remote locations. The data collected will provide a baseline on permafrost status at points across northern British Columbia, and will make it possible to recognize reductions in permafrost that could affect operations in forestry, oil and gas, and other industries.

FSP geomorphologists also examined 4000 years of landslide and climate history in the Hazelton Mountains in an attempt to uncover linkages between climate change and landslide frequency in this geomorphically active part of the province. Learning from the past sheds light on what may result from future changes in climate.

Future Forest Ecosystems Initiative: Building the Foundation for Policy Response

During 2008/09, many FSP specialists focussed on assembling and interpreting the relevant science regarding climate change for natural resources policy-makers. Under the integrated, multi-faceted, Future Forests Ecosystems Initiative (FFEI), FSP researchers on the FFEI Technical Team pooled their expertise in a coordinated and strategic manner to identify scientifically plausible future conditions, inform policy-makers of possible resource vulnerabilities, and make

recommendations for adaptation strategies. Specifically, FSP involvement included:

- projecting potential geographic shifts in Biogeoclimatic Ecosystem Classification (BEC) zones and tree species' ranges due to climate change. This information will be used to modify seed transfer and species selection guidelines so that plantations will be stocked with trees that are suitable for future climates.

- providing a vulnerability assessment of future risks to British Columbia's forest and range resources due to climate change. This assessment will be used to prioritize adaptation and stewardship efforts and develop policies for ameliorating these risks. Hydrological models were also examined to determine their suitability in exploring the effects of future climate change on watershed processes that are relevant to forest management.

- transforming the ClimateBC program, which is used to predict ecological changes and develop adaptation strategies, into Climate Western North America. This entails a tripling of the area currently covered so that climate regions outside of British Columbia that have conditions similar to those expected here in the future are captured.

A First for Forest Policy

Forest management achieved a new milestone in late 2008 when the MFR made the first adjustment to forest policy in Canada in response to climate change. The updated policy modified tree seed transfer standards to better match seedlot adaptation with current and future climates. The revision was based on analyses conducted by FSP forest geneticists, which examined the climatic distance seed is moved in response to varying elevational seed transfer limits. In light of changes to British Columbia's climate over the last century, and in anticipation of climate warming over the next 25 years, the geneticists recommended shifting elevational seed transfer limits upwards 100–200 m for most tree species. Increasing the upper elevational limit of seed transfer will help maintain healthy, productive forests, and capture gains obtained from decades of selective breeding.

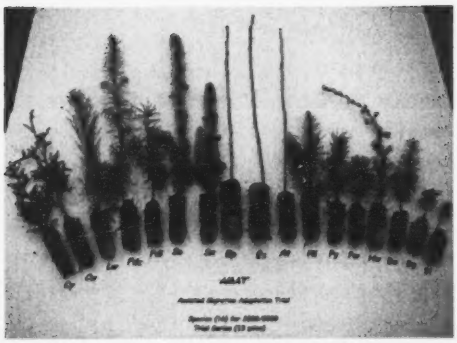
Assisted Migration Adaptation Trial lift wrapping crews.

Climate-based Seed Transfer

Recognizing that climate plays a key role in tree growth, survival, and health, FSP genetics researchers began examining opportunities to re-design British Columbia's seed transfer system to take advantage of advances in genecology, geographic information systems and climate models. Preliminary analyses show that a system based on climate rather than geography could result in a substantial improvement in health and growth, while increasing the number of square kilometres to which each seedlot could be deployed. In addition, a climate-based system would allow more effective implementation of assisted migration to help ensure that planted forests are adapted to current and future climates.

Assisted Migration Adaptation Trial

The Assisted Migration Adaptation Trial was established in 2008/09 to generate the first comprehensive data on climatic adaptation of tree species, and to identify species and seedlots that are best matched to current and future climates. The project will involve field testing genetically improved populations of 16 tree species at various locations from northern British Columbia into the United States. The first 40 000 seedlings for the trial were grown in nurseries this year and were planted in spring 2009.



The 16 tree species planted in 2009 for the Assisted Migration Adaptation Trial.

The growth and survival results from this trial will provide the first province-wide, quantitative evaluation of the long-term productivity of orchard (Class A) seedlots for all commercially important tree species in British Columbia, and will enable the development of reforestation strategies that are appropriate for climate change.

Modelling Forest Carbon

Research on carbon sequestration dynamics contributes to policies that address carbon as a forest commodity and a sustainability indicator. FSP researchers began using the Carbon Budget Model this year to explore how climate change could influence the carbon balance of British Columbia's forests over the next 50 years.

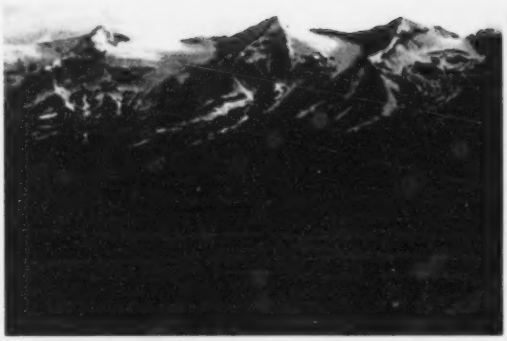
Stand development modellers also added carbon capabilities to their tree growth and yield models. They incorporated biomass equations into the Tree and Stand Simulator (TASS) to generate biomass and carbon storage information that is relevant for addressing questions about carbon sequestration. This will facilitate the incorporation of carbon information into the policy framework.

Classifying the Alpine

The classification of British Columbia's high-elevation ecosystems continued in 2008/09 as a means of improving the understanding of tree growth limits and climate change implications. With alpine and subalpine areas covering 15% of the province, this work addresses the largest gap in the BEC system, and constitutes the world's most detailed classification of alpine ecosystems. As the project neared completion this year, provisional zone and subzone maps were created, and classifications to the site association level were established.

B.2. Preparing for the Future with Foundation Research

The MFR has repeatedly benefitted from the foresight of researchers who years ago established core scientific research projects that now form an indispensable foundation for today's resource management. These projects, which include FSP foundation programs and long-term field experiments, provide baseline information on long-term response to forest management regimes, and thus enable researchers to evaluate responses to future climate change. The value of the more than 1400 experimental plots that have been established has grown through decades of persistent maintenance, refinement, and commitment.



Sampling alpine ecosystems in northwest British Columbia.

Foundation Programs

The FSP's foundation programs—Biogeoclimatic Ecosystem Classification, Tree Improvement, and Growth and Yield—are fundamental to the continual improvement in British Columbia's forest management and adaptation to climate change. BEC provides the ecological basis for many aspects of forest management, including silviculture interpretations and improved estimates of site productivity. Interior and Coastal Tree Breeding programs supply reforestation parent material that features superior growth rates and pest resistance. Stand Development Modelling generates the growth and yield estimates used for timber supply reviews and land use planning, and it enables silviculturalists to evaluate the cost-effectiveness of alternative forest management options. Researchers continue to develop, refine, and enhance these products to ensure the current and emerging needs of forest managers are addressed.

A lichen sample plot for research on caribou habitat.

Long-term Research Installations

Many FSP field experiments that were set up years ago are now efficiently answering resource management questions that were never contemplated when the research was first established. Several long-term installations were revisited this year to examine the impacts of the MPB and other current issues. These field investigations have produced insights that only long-term studies can generate:

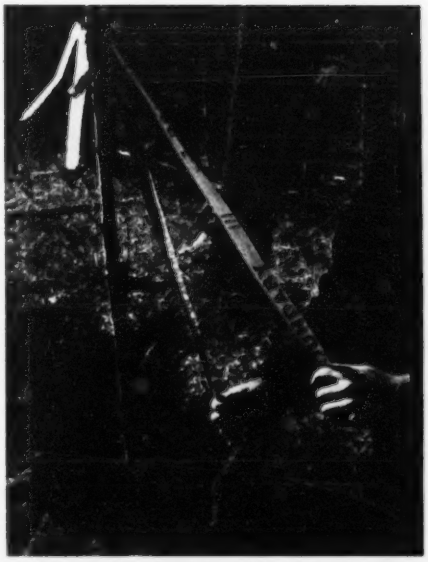
- It took more than a decade following group selection harvesting in mountain caribou winter habitat for a significant increase in lichen abundance on residual trees to become apparent. These findings, verified this year, are critical to shaping management prescriptions for modified harvesting to maintain critical caribou forage.
- Recent results at Carnation Creek showed that it may take decades for some forestry-caused alterations to fully emerge. A substantial decline in the watershed's Pacific salmon populations 30 years after logging was found to be directly attributable to experimental forestry activities reflecting historic practices used in the 1970s and early 1980s. As a result of this research at Carnation Creek and related studies conducted elsewhere in B.C., these practices are no longer used.
- Twenty-five years of remeasurements in second-growth coastal hemlock and Douglas-fir located on 85 sites has produced an unsurpassed amount of growth and yield data. The data have been used by provincial and international researchers to examine long-term stand development and treatment responses.
- The Flathead Research Installation is now in its 30th year of monitoring population dynamics, habitat use, and behaviour of grizzly bears in response to industrial activities. The project's exceptionally long history has garnered international recognition as a benchmark study of the relationships between industrial development and wildlife conservation values.
- The Long-term Soil Productivity (LTSP) study is now in its 15th year at some installations. It has recently attracted the collaboration of University of British Columbia professors, post-doctoral fellows, and graduate students who are using genomic approaches to monitor the impacts of both natural and human-related disturbances on the soil

Fitting a bear with a GPS collar to transmit the animal's location for wildlife habitat research.

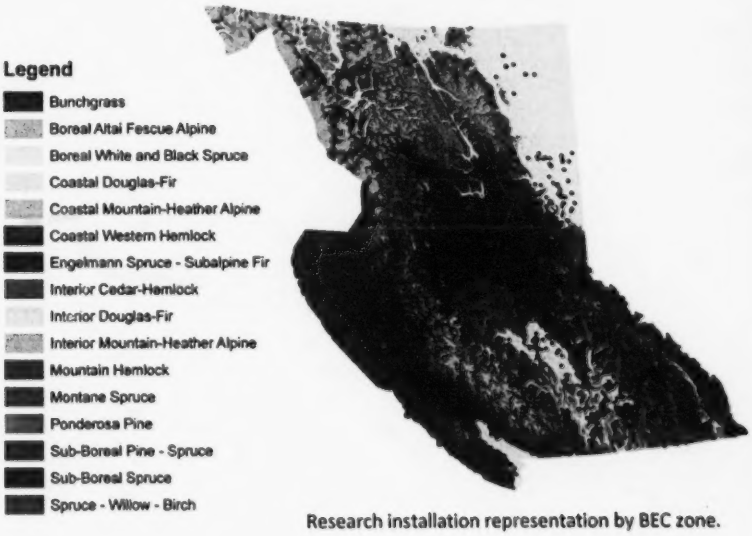
microbial community. These genomic tools are being used in the Sub-Boreal Spruce LTSP study to analyze the effects of experimental treatments on soil community composition and expression of key metabolic activities.

- Long-term research installations represent a substantial investment in data and knowledge that continues to accrue immense value. Designed to rigorous scientific standards, the sites provide multiple opportunities for future interdisciplinary research.

The Chief Forester and Forest Stewardship Division managers recently recognized the need for a strategic review of the FSP's long-term research field installations as a means of identifying those sites that are best suited to meeting future stewardship needs. By evaluating and prioritizing the utility of long-term installations established since 1910, FSP researchers identified a network of Living Forest Laboratories (166 experimental projects) that represent the most beneficial research. A companion FSP initiative involved identifying, mapping, and cataloguing research installations that are appropriate for safeguarding through the Plot Protection Project.



Protecting research plots.



Research installation representation by BEC zone.

C. Scientific Contributions to Ministry Priorities

The following sections highlight FSP research, extension, and consultation activities that were undertaken during the 2008/09 fiscal year in order to address specific MFR strategic priorities.

C.1. Addressing Impacts of the Mountain Pine Beetle Infestation

During 2008/09, the FSP was engaged in various capacities to address the impacts and implications of the MPB epidemic.

Hydrology and Soils

Work by FSP researchers on ameliorating the effects of the MPB and salvage harvesting on stand and watershed hydrology progressed on multiple fronts:

Soil pit in a lodgepole pine stand for a study characterizing the indicators of saturated soils prone to damage.

- At sites throughout the Central Interior, hydrologists investigated how the MPB and timber harvesting influence snow hydrology. The purpose was to address concerns that both tree mortality from bark beetles and rapid salvage logging can cause increased peak streamflows and associated erosion and flooding, which can damage private property and fish habitat. The research results offer guidance on planning forest operations to minimize peak streamflow increases in beetle-attacked watersheds.

- Recognizing sites that have saturated soils prior to harvesting enables foresters to plan their operations so as to avoid causing soil rutting and compaction. The need for predictive tools has been especially apparent in areas affected by the MPB, where saturated soils are being encountered more frequently. Research on threshold conditions that indicate the likelihood of saturated soils formed the basis of a decision support tool that allows broad-scale assessments of existing hydrologic conditions to be made. This tool can be used along with field cards that help identify the highest risk sites.

Genetic Resistance

Based on observations of MPB attacks at progeny test sites and at the Kalamalka seed orchard, researchers found that certain lodgepole pine genotypes are resistant to the bark beetles. Subsequent investigations revealed that some chemical compounds and bark roughness features contribute to beetle resistance. This work may lead to opportunities for selectively breeding beetle-resistant trees.

Seed Production

In response to the sudden increase in demand for lodgepole pine to reforest interior British Columbia, tree breeders completed a multi-year program to augment the parent stock of lodgepole pine seed orchards, and thereby expand seed production from genetically selected trees. Meanwhile, in two seed planning zones where no genetically improved material currently exists, five-year-old provenance trials that were established to screen for superior families produced their first growth performance measurements. These trials provided timely information to the forest industry on lodgepole pine provenances that will grow the most productive second-growth stands.

C.2. Examining Factors Affecting Midterm Timber Supply

Mitigating the decline in midterm timber supply following the MPB epidemic is a priority for sustaining British Columbia's interior forest industry and forestry-dependent communities. FSP research in 2008/09 worked towards improving estimates of forests suitable for midterm harvesting and enhancing their productivity.

Secondary structure in a lodgepole pine forest previously infested with mountain pine beetle.

Determining What Remains After the MPB

Little is known about the health and abundance of understorey trees that have survived the MPB infestation. Knowledge of secondary structure in pine forests is now necessary to assess and optimize midterm harvesting opportunities. To address this knowledge gap, researchers re-examined historical tree data from various research plots and assembled descriptions of understorey tree growth in three TSAs. This information was compiled in a database for forest managers.

FSP scientists developed methods for quickly identifying where advanced regeneration is of sufficient density to serve reforestation needs in the Montane Spruce biogeoclimatic zone. These estimates of midterm timber supply will aid forest managers in evaluating which MPB-attacked stands can regenerate without intervention.

Old Plots Offer Insights

Several long-term research trials provided information this year on the recovery of stands after removal of mature pine. One trial in central British Columbia, which has produced 40 years of data on the performance of regenerating spruce trees in partially cut pine stands, revealed how young spruce trees respond after the overstorey is killed by the MPB. In southeastern British Columbia, a 15-year-old silviculture systems experiment provided data on how mixed stands of Douglas-fir, larch, and pine develop once the pine is harvested.

Reconstructing plots at an old silviculture trial.

Researchers revisited this trial and collected data on tree regeneration and growth for the purpose of interpreting how mixed stands develop after MPB infestation. Stand development modellers will use the data to project growth and yield of these complex stands, and extrapolate that information to the midterm timber supply. The data will also be used to assist foresters with developing management prescriptions.

Repressed Pine Has Potential

The Chilcotin Plateau supports dense stands of slow growing lodgepole pine that seeded in after large wildfires, decades ago. Although these stands are believed to be incapable of accelerated growth, FSP researchers have discovered how to revitalize these forests. Assessment of research plots this year showed that the repressed pines responded vigorously to fertilization, which offers a significant contribution to the midterm timber supply. Not only are the trees already well beyond the seedling stage, 100 000 hectares of the dormant stands are currently partially excluded from the timber supply in an area that has been devastated by the MPB.

Growing Quality Wood

Stand development modellers have incorporated the wood quality attributes of interior spruce and lodgepole pine into the TASS model. This will improve estimates of wood volume and value produced under different silvicultural treatments, and will guide stand management strategies for interior forests.

C.3. Intensively Managing Coastal Forests

FSP activities in 2008/09 directly supported the Coastal Forest Action Plan's strategies of shifting harvesting to second-growth forests and hardwood tree species to achieve the goal of a competitive coastal forest sector. In doing so, researchers focussed on growing better trees and growing trees better.

Improving Trees

- As part of the FSP Coastal Tree Breeding program, coastal Douglas-fir parent material for seed orchards was identified and propagated based on progeny test data from third-generation breeding stock. Forest geneticists calculated breeding values of 100 families to select trees that at rotation age are capable of producing 25–30% greater wood volume than that of natural, unimproved stock.

- A yellow-cedar clonal hedge orchard that produces 20% volume gain over wild sources was established at the Cowichan Research Station and was made available to industry and BCTS for cuttings.

- Breeding of western redcedar trees that were selected for their resistance to deer browsing produced third-generation trees with elevated levels of foliage terpene, which rendered them less palatable to deer. Analyses of the newest progeny determined that the enhancement of terpene does not sacrifice tree productivity. The research offers some promising solutions to the widespread problem of deer damaging young western redcedars, which is presently addressed in British Columbia by spending $20–25 million annually on installing protective seedling cones.

Breeding western redcedar for genetic selection of trees with increased foliar terpenes to deter deer browsing.

- Improved genetic stock from second-generation progeny tests for maritime low-elevation western hemlock was selected to supply seed orchards. Compared with wild western hemlock trees, the second generation produces 23–25% more wood at rotation age.

- The establishment of red alder clone banks of genetically selected stock that at rotation age will produce up to 29% more wood volume than unselected sources was completed this year.

- Provenance trials for bigleaf maple were initiated to examine the genetic basis of the tree's performance.

Operational trials, like this one near Oona River on British Columbia's north coast, are yielding valuable information on harvesting feasibility, regeneration, and second-growth productivity within cedar-dominated stands that dominate the outer coast.

Improving Stands

- This year, data collected from seven-year-old operational trials that have been used to monitor western redcedar regeneration and growth on the North Coast confirmed the recommendations produced earlier from the Pattern, Process, and Productivity in Hypermaritime Forests (HyP^3) research project. When the guidelines are followed for harvesting and silviculture of redcedar in areas previously considered inoperable because of wet soils, the species regenerates and grows wells. Indeed, second-growth stands are considerably more productive, as reflected in the site indexes: 10 for old-growth, 18 for second-growth.

- To better estimate growth and yield of coastal balsam fir, the FSP began a multi-year project to incorporate the species into TASS III. This will improve the model's fidelity for balsam fir, which currently is modelled with surrogate data.

C.4. Assessing Implications of Partial Harvesting

FSP researchers investigated partial harvesting in various ecosystems around the province this year, and arrived at significant findings for forest management.

Destructive stem gall on understorey coastal Douglas-fir at the Roberts Creek Study Forest partial-cutting trial.

Unexpected Results from Partial Cutting

Field research at the Roberts Creek Study Forest, a long-term partial-cutting trial, showed that after 15 years, unusual galls on branches and stems of coastal Douglas-fir had multiplied, grown to the size of softballs, and weakened tree stems enough to cause breakage. With 40% of the understorey Douglas-fir infected 15 years after partial harvesting, its value as a timber crop was lost. This investigation is the first to report the bacteria-induced canker on young Douglas-fir trees. As the rare disease appears to be facilitated by retention harvesting, its unforeseen destruction presents new considerations for regenerating these types of partially cut stands.

Partial Cutting in Wet Coastal Forests

Partial cutting treatments that were previously established on Haida Gwaii were revisited this year to examine the relationships of overstorey composition and canopy openness with the growth of regenerating Sitka spruce, western hemlock, and western redcedar. This investigation is the first to scientifically quantify tree regeneration and growth in residual stands in British Columbia's wet coastal ecosystems where Douglas-fir is not dominant.

This past year, results regarding timber supply implications were presented to a diverse audience, including the Chief Forester; MFR branch, regional, and district staff; and the Prince Rupert TSA Steering Committee. The study's findings will inform guidelines developed for partial harvesting and regeneration on British Columbia's central and north coasts.

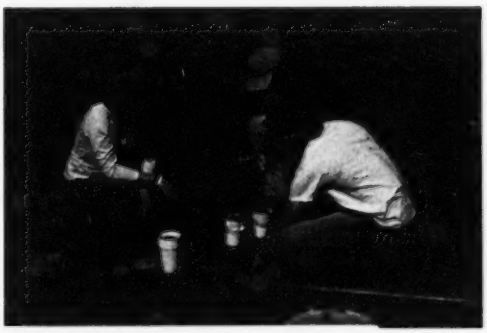
Using Shelterwood Systems to Regenerate Douglas-fir

In one Central Interior BEC subzone, sites that are highly productive for Douglas-fir have been difficult to regenerate after clearcutting. Douglas-fir seedlings on these sites suffer high mortality rates because they do not tolerate repeated frosts. Rather than convert these prime Douglas-fir growing sites to lodgepole pine, a local group of foresters proposed using uniform shelterwood systems to improve regeneration of Douglas-fir. FSP researchers remeasured natural regeneration under a range of residual basal areas. So far, the project has demonstrated successful establishment and growth of Douglas-fir on these sites, which has lead to recommendations for shelterwood applications. The final overstorey removal is planned for 2010, at which time further regeneration assessment will be undertaken.

C.5. Sustaining Range Resources

During 2008/09, FSP range ecologists, plant ecologists, silviculturists, and others assisted the Range Branch, forest districts, and ranchers with initiatives aimed at improving range management. These included:

- assessing the health of grazed fescue grasslands in an experiment that was designed to develop systems for quickly evaluating grassland vigour and identifying management thresholds.
- testing livestock management techniques on rangelands where dense lodgepole pine stands no longer form natural range barriers. The livestock controls were aimed at drawing cattle away from sensitive wet meadows and preventing intermixing of herds.
- assisting Rocky Mountain and Arrow Boundary Forest Districts with the planning of grassland ecosystem restoration programs to reverse tree encroachment.



Rangeland health research.

- preparing BEC field guides on the province's grasslands. The guides incorporate the newly established site-series level classification of Cariboo rangeland ecosystems, and are intended to be used by ranchers, ecologists, and land managers. Field data were also collected to fill BEC sampling gaps for shrub draws, saline meadows, and grasslands in the Southern Interior.
- conducting a Range Reference Area tour on succession and disturbance in aspen-dominated communities. The tour was designed to assist the Range Branch in developing a consistent classification of range plant communities that links to site productivity.
- examining forage production and timber growth under various silviculture treatments at the Isobel research project to test prescriptions for creating and maintaining open canopy conditions in dry Douglas-fir forests. Data collected on vegetation responses to livestock grazing, timber harvesting, and site preparation will be used to develop prescriptions that cost-effectively promote open canopy conditions in dry Douglas-fir forests while maintaining timber, forage, and ecological values. The research will also inform fuel management strategies and ecosystem restoration approaches. Field tours of the project were hosted for district and BCTS staff, and for an international forestry conference.

Extension tour of dry Douglas-fir forest at the Isobel research project.

C.6. Guiding Integrated Forest Management

Many FSP projects are designed to study the response of multiple forest values so that effective management recommendations for optimizing multiple objectives can be developed. This section presents examples of FSP research, extension, and consultation that was conducted during 2008/09 to advanced integrated forest management.

Ecosystem-based Management

Many Coast Forest Region researchers helped develop recommendations for coastal Ecosystem-based Management (EBM) by participating in various working groups. FSP specialists provided expertise on adaptive management, watershed hydrology, Marbled Murrelets, tailed frogs, and ecological representation, among other aspects of EBM. The specialists also initiated field research to build knowledge that supports EBM. Projects included examining partial cutting of coastal forests as a means of maintaining non-timber forest values, and characterizing old-growth forest structure and dynamics to provide a basis for EBM standards.

Wildlife Tree Patches

Determining whether wildlife tree patches in clearcuts continue to provide habitat and stand-level biodiversity values over the stand rotation is critical for incorporating mature forest habitat values into the design of cutblocks. Two projects in central British Columbia were undertaken this year to determine how well retention patches sustain habitat and biodiversity. One study tracked windthrow and stand structure, while the other involved inventorying the richness of bryophyte and macrolichen species. The results confirmed that patch size has a major influence on species richness and that large patch size is beneficial.

Downed logs in larger mature forest patches maintain a higher diversity of bryophytes and lichens than those in smaller patches.

C.7. Building Collaborative Relationships with First Nations

FSP ecologists worked with First Nations groups this year to enhance productivity of important traditional use plants and to develop First Nations' resource capacity in the areas of knowledge building and economic value.

Enhancing Productivity of First Nations' Plants

FSP researchers helped First Nations groups at Williams Lake, Burns Lake, and Haida Gwaii (Queen Charlotte Islands) identify the ecological factors that influence productivity of their culturally important plants. Both traditional and western scientific knowledge were used to inventory and map the most productive ecological conditions for these plants. The research distinguished site and climatic variables that produce the highest value or greatest abundance of berries, birch bark, and other products. In addition to helping classify high productivity sites for First Nations plants of economic or cultural value, this research will aid the planning of harvesting areas, timing, and practices that will maintain or enhance the non-timber resources First Nations value.

Surveying culturally important plants on the Queen Charlotte Islands.

Exclosure to prevent deer from browsing forest plants on the Queen Charlotte Islands.

Bringing Back Traditional Plants

Deer, which were introduced to Haida Gwaii, have nearly extirpated some forest plants that are valued by the Haida First Nation. FSP ecologists, in collaboration with Royal Roads University and the Haida Guardians, compared the abundance of vegetation in similar ecosystems on the islands and the mainland. The aim was to identify sites on Haida Gwaii that have the greatest potential for producing culturally important plants once deer are excluded.

Collaborating and Building Capacity

Research on old-growth forest structure will provide coastal forest managers with much needed ecological benchmarks against which to evaluate the results of harvesting practices. An FSP study, begun this year, established the first permanent network of old-growth plots for coastal British Columbia, and included the Kitlope Valley, the traditional territory of the Haisla First Nation. Haisla members were hired to provide logistical support for the Kitlope field study, and together, opportunities for further research collaboration were explored.

C.8. Conserving Species at Risk

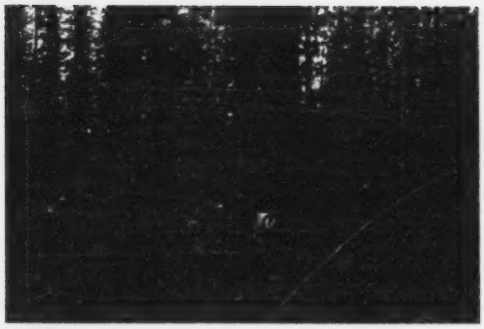
Developing, testing, and refining methods for managing species at risk was a focus for FSP wildlife habitat specialists in 2008/09. While their activities involved many vertebrate species, the bulk of their research focussed on the province's threatened and endangered ecotypes of woodland caribou.

Woodland Caribou

FSP projects aimed at confirming strategies for managing forest habitat to sustain caribou proceeded on several fronts during 2008/09, and included:

- quantifying the forest stand and landscape attributes that influence mountain caribou habitat and predation rates. The aim of this work was to unravel the relationship between landscape patterns of forest harvesting, which can result in habitat fragmentation, and abundance of primary prey species.
- assessing how well silvicultural systems can sustain mountain caribou winter habitat. This study showed that group selection harvesting can promote growth of arboreal lichen forage, a finding that has implications for forest harvesting on 53 000 hectares of high-elevation caribou range.

- examining the impacts of the MPB infestation within the Itcha-Ilgachuz woodland caribou herd's range. This study will be used to guide the planning and management of modified harvesting on more than 180 000 hectares of caribou habitat in the West Chilcotin.
- evaluating the effectiveness of ungulate winter ranges (UWRs) that were established for the northern ecotype of woodland caribou in the South Peace. The purpose was to verify that the UWRs meet the herds' needs.
- documenting the Kennedy Siding caribou herd's use of UWR to evaluate the range's effectiveness as habitat after it was infested with the MPB and a portion of it was salvage logged. This study will be used to guide management of this herd and 136 000 hectares of other caribou habitat in the Northern Interior Forest Region.



Woodland caribou in a stand that was infested with mountain pine beetle.

Birds, Mammals, Amphibians, and Ecosystems

This year FSP wildlife habitat ecologists contributed to habitat plans, recovery strategies, management plans, operational guidelines, and habitat classification standards for species at risk. FSP researchers worked collaboratively in recovery teams for the Spotted Owl, Marbled Murrelet, Northern Goshawk, mountain caribou, Queen Charlotte Islands ermine, Queen Charlotte Islands Northern Saw-whet Owl, and the Garry Oak ecosystem. Their involvement included research and reporting on testing of standards for classifying Marbled Murrelet habitat along the British Columbia coast, and assessing the implications of proposed changes to landscape planning for Spotted Owl recovery. Research was also initiated to evaluate enhanced nest area habitat for Spotted Owls in the Chilliwack and Squamish Forest Districts, and to determine the effectiveness of coastal tailed frog management in the North Coast and Kalum Districts.

C.9. Enhancing Tree Seed Orchard Production

The FSP Cone and Seed Pest Research program, based at the Kalamalka Research Station, is considered to be among the world's best. This year, studies of several damaging tree seed orchard pests made substantial headway.

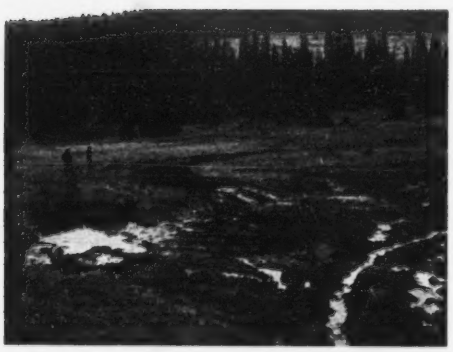
Significant progress was made in understanding the western conifer seed bug, a primary orchard pest that destroys seeds of many conifer species. Mark-and-recapture studies of the seed bug unexpectedly revealed the insect's strong attraction to certain tree genotypes; this attraction is associated with a specific phenol signature of cones from the attractive genotypes. It was also discovered that seed bugs find cones on host plants by sensing infrared radiation emitted by the cones; this is the first documentation of any herbivorous organism, other than those associated with fire, using infrared to locate plant hosts. Both these discoveries open up opportunities for trapping, monitoring, and controlling insects in tree seed orchards.

Collecting western conifer seed bugs at a tree seed orchard.

The FSP's cone and seed pest specialist also provided information on pest research and specific pest management issues to staff at the Tree Improvement Branch and at seed orchards and tree nurseries. This extension included making presentations at meetings, giving informal talks, and preparing a cone and seed pest identification guide for British Columbia.

C.10. Supporting *Forest and Range Practices Act* Implementation

FSP specialists directly supported implementation of the *Forest and Range Practices Act* (FRPA) during 2008/09 by providing expertise, conducting reviews, and performing assessments in response to specific requests from district and BCTS staff throughout the province.



Soil damage by off-road vehicles in a high-elevation meadow.

Soil Disturbance

FSP soils specialists assisted district compliance and enforcement (C&E) staff with investigations of excessive soil disturbance that resulted from forestry activities. The specialists appeared as expert witnesses, made recommendations for rehabilitation, and provided expert opinion on environmental damage. Researchers also provided advice on avoiding soil damage at individual sites. Furthermore, FSP soils specialists consulted with MFR and BCTS Executive regarding detrimental soil disturbance that was occurring during salvage harvesting of MPB-infested stands, and they provided guidance to forest managers on soil conservation in salvage operations.

Consultation by FSP staff on hydrology, terrain stability, forestry roads, and biodiversity covered a wide range of situations. Examples of FSP researchers directly assisting MFR staff and others with specific FRPA-related concerns during 2008/09 included:

Hydrology

- advising Quesnel Forest District staff about hydrologic recovery for Kersley Creek.
- giving guidance to BCTS on watershed and stream channel responses to intense MPB salvage logging in the Upper Nicola Valley, as well as completing watershed assessments and making recommendations for sustainable forest planning and operations on 75 000 hectares of coastal BCTS business areas.
- providing site-specific consultations to BCTS and First Nations licensees on the implications of forest harvesting for groundwater.

Terrain Stability and Soil Erosion

- advising BCTS on road washouts, harvesting on steep slopes, and causes of landslides, assessing windthrow and gully slope stability in the Chinook Business Area, and conducting Terrain Stability Assessments at various locations throughout the province.
- conducting investigations for C&E staff on landslides and erosion triggered by roads and soil disturbances in southeast British Columbia, and evaluating landslide and sedimentation concerns in the South Island District.

Investigating a landslide.

Forest Roads

- assisting BCTS in preparing a road management plan to prioritize inspection and maintenance of a road network in the Seward-T'lastsa Business Area and to address issues concerning deactivation, liability, and risk; providing guidance on a hydrologic assessment of stream flood frequency to determine the most cost-effective sizing for culverts that meet FRPA requirements; and conducting an assessment to resolve difficulties in maintaining a forestry road where it crosses alluvial fans in the Holmes River valley near McBride.
- reviewing and making recommendations to MFR district staff on redesigning the Morice River Road to stabilize a segment that has repeatedly been subjected to landslides.

Sampling creek sediment.

Biodiversity and Habitat

- providing advice to BCTS and MFR districts on harvesting proposals for areas that contain wildlife features, such as a goshawk nest or an ungulate mineral lick.
- assisting district managers with the classification of Marbled Murrelet habitat.

- informing staff within MFR districts, the Kamloops Fire Centre, and the Ministry of Environment of the habitat implications of fuel management strategies.

C.11. Knowledge Transfer

One of the FSP's most important functions is to extend research results and scientific expertise to Ministry staff and field practitioners. During 2008/09, this was accomplished through a variety of mechanisms, including training workshops, field tours, and extension publications.

Mule deer winter range can be maintained while harvesting timber.

Training on Forest and Range Practices Act Requirements

In addition to the consultations on FRPA implementation described previously, FSP specialists provided more general guidance through formal extension activities:

- Watershed-level fan management strategies that address the risks of destabilizing alluvial fans were shared via field workshops, conferences, office presentations, and an MFR Land Management Handbook.
- Training sessions on Government Action Regulations, General Wildlife Measures, and management plans for mule deer winter ranges were given in the Cariboo-Chilcotin area.
- Workshops were provided on invasive plant identification, soil disturbance issues and management considerations, and the role of large woody debris in riparian zones.

Extension tour of dry Douglas-fir forest at the Isobel research project.

Promoting Improved Trees

Newly available pest-resistant planting stock promises to boost the ecological and commercial value of British Columbia's plantations. As a result, forest geneticists offered information to encourage reforestation with these genetically improved trees. Foresters from the MFR and industry also attended a Western White Pine Management and Genetics workshop where they learned about western white pine resistance to white pine blister rust. In addition, geneticists published a technical report to promote the inclusion of Sitka spruce in the coastal planting mix. They documented how selective breeding programs have diminished the threat of the spruce terminal weevil, a major pest that distorts the form of western spruces.

C.12. Improving Management Processes

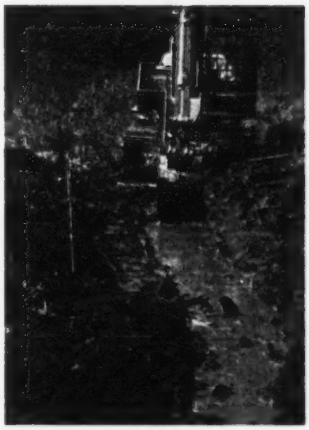
During 2008/09, FSP staff were called upon by branches, regions, and districts throughout the Ministry to apply their skills and expertise to improving management and administrative processes.

Creating Solutions with Biometrics

FSP biometricians assisted the Economics and Trade Branch in simplifying and improving the stumpage system by developing methods to predict geographical zones of minimum stumpage based on available billing data. They also aided the Revenue Branch in choosing a new sampling algorithm for the provincial weight-scaling system to meet the Ministry's requirements for a defensible and unpredictable way of selecting trucks for scaling, while still maintaining enough flow to not unduly disrupt industry operations. Biometricians also assessed the impacts of kiln-drying on the composition of grade 4 scaled volume so that the percentage of grade 4 lodgepole pine dry wood in a cruise could be predicted quickly.

New Technique for Rehabilitating Drainage

A site with a dead stand of lodgepole pine can have wetter than normal soil conditions, an elevated water table, and excessive water pooling compared to sites with living stands. To address this concern, FSP researchers initiated a project to evaluate the effectiveness of digging ditches to restore a cutblock's natural water drainage patterns. The results of this study were used to produce a field card to assist forest managers in prescribing the size and location of remedial ditching. By reducing standing water, remedial ditching improves site access, stimulates forest regeneration, and enhances tree productivity.



Digging a ditch to reduce standing water.

Managing Emerging Post-wildfire Hazards

The aftermath of the severe 2003 wildfire season resulted in large scale flooding, erosion, and property-destroying debris flows that originated from five fire sites. Until then, such wildfire-related events had rarely been documented in British Columbia. To minimize and manage the risks from this burgeoning hazard, FSP researchers investigated the conditions that led to dangerous post-fire events. As well, FSP staff worked with the Protection Branch to develop Standard Operating Procedures and Policy for Post-wildfire Natural Hazards Risk Management. Under the new policy, the MFR regions have specialists conduct site assessments of the risks of flooding, soil erosion, and landslides after a wildfire.

Water repellent soils testing.

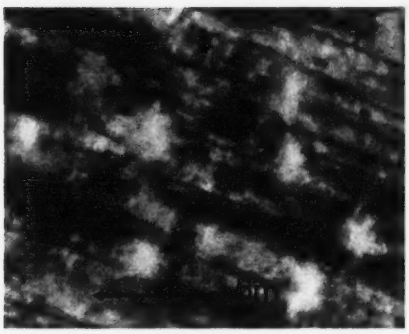
Soils extension tour of a salvage harvesting operation.

Innovative Soil Stewardship Monitoring Approaches

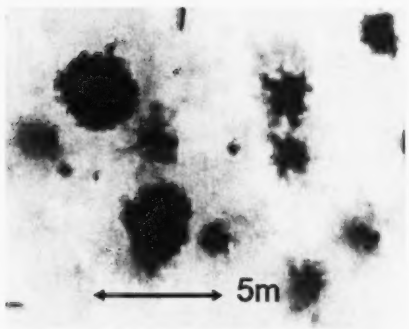
This year the Forest Practices Branch, along with the forest districts and FSP soils researchers, launched the provincial soils stewardship monitoring component of the Forest and Range Evaluation Program (FREP). To bring soils monitoring to field practitioners, researchers developed some innovative technological tools and applications. The new monitoring methods rely on using digital imagery, both at the office and in the field, for collecting data on indicators and measures. Directly recording field data onto digital images greatly enhances the efficiency and accuracy of documenting and compiling measurements. Extending the soils monitoring protocols to the districts involved designing and delivering a week-long training course, preparing user guides, and producing soil conservation evaluation field cards for district staff.

Evaluating a New Stocking Standard Survey Method

The Fort St. John Pilot Project was established by regulation in 2001 to enable innovative forest practices while streamlining administration. As one of their innovative forest practices, Pilot Project proponents developed a landscape-level reforestation strategy that involves surveying and reporting of multiple conifer plantations. In support of the Pilot Project's scheduled review by the Ministry of Forests and Range, FSP researchers evaluated the methodology and reported their findings and recommendations for improvement to Pilot Project participants, the Chief Forester, and staff from the ministries of Forests and Range and Environment responsible for administering the project.



The air photo above is the same site as the one below, taken under cloudy skies in winter brings out the details of understory conifers.



New Applications for Aerial Photography

While working on a snow hydrology project, an FSP hydrologist developed a novel approach to aerial photography that produces exceptionally detailed images. He had aerial photos taken of his plots within MPB-attacked stands in winter and beneath cloud cover. The diffuse light in the snow photos caused secondary forest structure at all canopy levels to display with unusual clarity. This year an FSP investigation into the technique's reliability showed that interpretations of these aerial photos are highly accurate. Winter aerial photography is particularly useful for assessing secondary structure in stands that are affected by the MPB. It also provides unprecedented detail, accuracy, and cost-efficiency, which assists forestry companies in meeting recently implemented harvesting requirements. As news of this methodology spread, a number of resource managers expressed interest in using snow photography for other purposes.

Appendix A – Forest Science Program Clients

B.C. Conservation Data Centre
B.C. Integrated Land Management Bureau
B.C. Ministry of Energy, Mines and Petroleum Resources
B.C. Ministry of Environment
B.C. Oil and Gas Commission
BC Parks
BC Timber Sales
Canadian Avalanche Association
Canadian Council of Forest Ministers
District of Kitimat
Energy companies
Forestry companies and consultants
Forests for Tomorrow
Gitanyow Fisheries Authority
Haida First Nation
Kamloops Future Forest Initiative
MFR BC Wildfire Management Branch
MFR Chief Forester
MFR Forest Districts
MFR Economics and Trade Branch
MFR Forest Analysis and Inventory Branch
MFR Forest Practices Branch
MFR Range Branch
MFR Regional and Divisional Management Teams
MFR Revenue Branch
MFR Tree Improvement Branch
Nature Conservancy of Canada
Parks Canada
Ranching industry
Seed orchards
University students
U.S. Department of Agriculture
Yukon Government

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MFR Regional and Divisional Management Teams
MFR Revenue Branch
MFR Tree Improvement Branch
Nature Conservancy of Canada
Parks Canada
Ranching industry
Seed orchards
University students
U.S. Department of Agriculture
Yukon Government

Appendix B – Forest Science Program Partners and Collaborators

Alex Fraser Research Forest
Association of Professional Engineers and Geoscientists of British Columbia
Forest Genetics Council of British Columbia
BC Forest Practices Board
B.C. Integrated Land Management Bureau
B.C. Ministry of Agriculture and Lands
B.C. Ministry of Environment
BC Parks
BC Timber Sales
Bulkley Valley Centre for Natural Resources Research and Management
Burns Lake Community Forest
Canadian Association of Petroleum Producers
Canadian Forest Service
Canadian Institute for Climate Studies
Canfor
Council of Forest Industries
Council of the Haida Nation
Fisheries and Oceans Canada
Food and Agriculture Organization of the United Nations
Forestry Commission of Great Britain
FORREX Forum for Research and Extension in Natural Resources
FP Innovations
French National Institute for Agricultural Research
Gorman Brothers Lumber
Government of Alberta
Government of Newfoundland and Labrador
Haida Guardians
Haisla First Nation
Hardwood Silvicultural Cooperative
Inland Empire Tree Improvement Cooperative
Institute of Ecosystem Studies (New York)
Interfor
Island Alpine Guides
Island Timberlands
L & M Lumber
Mathematics of Information Technology and Complex Systems
MFR Forest Analysis and Inventory Branch
MFR Forest Districts
MFR Forest Practices Branch

Appendix B – cont'd

MFR Protection Branch
MFR Range Branch
MFR Forest Regions
MFR Tree Improvement Branch
Mt. Cain Ski Hill
NatureServe
North American Long-term Soil Productivity Experiment
Northern Health Authority
Northwest Tree Improvement Cooperative
Oregon Department of Forestry
Oregon State University
Pacific Climate Impacts Consortium
Parks Canada
Provincial Emergency Program
Queen's Printer
Quinault Indian Nation (Washington State)
Royal BC Museum
Royal Roads University
Saskatchewan Research Council
Scott Paper
Selkirk College
Simon Fraser University
Stand Management Cooperative
Sustainable Forest Management Network
Swedish University of Agricultural Sciences
T'exelc First Nation
Tembec Forest Industries
The Nature Conservancy of Canada
Thompson Rivers University
TimberWest Forest Corp
Tolko Industries
U.S. Forest Service
U.S. Geological Survey
U.S. National Park Service
University of Alberta
University of Arizona
University of British Columbia—Okanagan
University of British Columbia—Vancouver
University of Freiburg (Germany)
University of Lethbridge
University of Montana
University of Northern British Columbia

Appendix B – cont'd

University of Ottawa
University of Quebec
University of Victoria
University of Washington
University of Zurich (Switzerland)
Utrecht University (Netherlands)
Vancouver Island University
Village of Queen Charlotte
Washington State Department of Natural Resources
Water Survey of Canada
West Fraser Timber
West Moberly First Nation
Western Forest Products
Weyerhaeuser
Xats'ull First Nation

Forest Science Program
Staff Locations

Research Branch: Victoria, Saanich (North Road Laboratory), Cowichan Lake and Kalamalka Research Stations, Kamloops, Prince George, University of British Columbia, Revelstoke, Smithers

Coast Forest Region: Nanaimo, Smithers, Victoria

Northern Interior Forest Region: Prince George, Smithers, Dawson Creek, Victoria

Southern Interior Forest Region: Kamloops, Williams Lake, Nelson

Forest Science Program
Organizational Structure

Research Branch and Regional Forest Science Sections and Disciplines

ECOLOGY AND EARTH SCIENCES

- BEC–Plant Ecology
- Climatology and Soil Conservation
- Mountain Pine Beetle
- Silviculture Systems and Forest Dynamics
- Watershed Research
- Wildlife Habitat, Range Ecology, and Non-timber Forest Resources

FORESTRY AND TECHNICAL SERVICES

- Analytical Laboratory
- Stand Development Modelling
- Strategic Analysis (Biometrics, and Landscape Ecology Modelling)
- Finance and Administration
- Technical Communications (Library, Knowledge Management, and Production Resources)

FOREST GENETICS

- Coastal Tree Breeding
- Cone and Seed Pest Research
- Forest Genetics Research and Management
- Interior Tree Breeding
- Research Stations

NORTHERN INTERIOR FOREST REGION

- Climatology
- Ecology
- Geomorphology
- Hydrology
- Silviculture
- Soils
- Wildlife Ecology

SOUTHERN INTERIOR FOREST REGION

- Geomorphology
- Hydrology
- Plant Ecology
- Silviculture Systems
- Soils
- Wildlife Ecology

COAST FOREST REGION

- Forest Ecology
- Geomorphology
- Hydrology
- Silviculture Systems
- Soils
- Wildlife Habitat Ecology